
XXVII. *Remarks on the Pulvilli of Insects.* By John Blackwall, Esq., F.L.S.

Read, February 1, 1831.

IN the *Physico-Theology* of Dr. Derham, p. 363, note b, it is stated that “diverse Flies, and other Insects, besides their sharp hook’d Nails, have also skinny Palms to their Feet, to enable them to stick on Glass, and other smooth Bodies, by means of the Pressure of the Atmosphere.” This opinion, which appears to be almost universally adopted by the entomologists of the present day, has derived additional weight from the investigations of Sir Everard Home, whose papers relative to this curious subject, illustrated by figures of the parts employed in climbing, engraved principally from drawings made by Mr. Bauer, are published in the *Transactions of the Royal Society* for 1816. These researches are regarded by Messrs. Kirby and Spence (see their *Introduction to Entomology*, vol. ii., Letter xxiii.) as having “proved most satisfactorily, that it is by producing a vacuum between certain organs destined for that purpose and the plane of position, sufficient to cause atmospheric pressure upon the exterior surface, that the animals in question are enabled to walk up a polished perpendicular, like the glass in our windows, or with their backs downward on a ceiling, without being brought to the ground by the weight of their bodies.” To dissent from a theory so generally received, including among its advocates numerous illustrious names, may, perhaps, be deemed

presumptuous; nevertheless, as facts absolutely irreconcilable with this supposition have been forced upon my attention, while engaged in examining the evidence by which it is supported, I shall, with every sentiment of respect for the high authorities to whom I stand opposed, submit my views to the consideration of candid and intelligent naturalists.

Concerning the structure of the instruments by means of which flies ascend the vertical sides of smooth bodies, various opinions have been promulgated. Some authors compare them to sponges, and conjecture that they are designed to contain a glutinous secretion capable of adhering to well cleaned glass. Dr. Hooke describes them as palms or soles beset underneath with small bristles or tenters, like the wire teeth of a card for working wool, which he conceived give them a strong hold upon objects having irregular, or yielding surfaces; and he imagined that there is upon glass a kind of smoky substance penetrable by the points of these bristles*. According to the observations of Sir Everard Home, they are expanded membranes, having their inferior surface granulated, and their edges beautifully serrated†; while Messrs. Kirby and Spence, on the contrary, remark that they are downy on the underside and granulated above‡.

The want of accordance so conspicuous in the preceding accounts induced me to inspect the parts minutely under a good compound microscope, when it was immediately perceived that the function ascribed to them by Dr. Derham and Sir E. Home is quite incompatible with their organization. Minute hairs, very closely set and directed downward, so completely cover the inferior surface of the expanded membranes, improperly deno-

* *Micrographia*, p. 170-171.

† *Transactions of the Royal Society* for 1816, p. 323.

‡ *Introduction to Entomology*, vol. ii., Letter XXIII.

minated suckers, with which the terminal joint of the tarsi of flies is provided, that it cannot possibly be brought into contact with the objects on which those insects move, by any muscular force they are capable of exerting: the production of a vacuum between each membrane and the plane of position is therefore clearly impracticable, unless the numerous hairs on the underside of these organs individually perform the office of suckers, and there does not appear to be anything in their mechanism which in the slightest degree countenances such a hypothesis. When highly magnified, their extremities, it is true, are seen to be somewhat enlarged; but, whether they be viewed in action or in repose, they never assume a figure at all adapted to the formation of a vacuum.

Satisfied that this difficult problem must admit of a solution more consistent with the various phenomena it comprehends than the popular one here controverted, I determined to institute an experimental investigation of it. Accordingly, having procured living specimens of the House-fly, *Musca domestica*, and of the large Flesh-fly, *Musca vomitoria*, I inclosed them in clean jars and phials of transparent glass, the interior surface of which they traversed in every direction with the greatest facility, walking upon it even with their backs downward, while they remained in full vigour; but when enfeebled by exposure to cold, or when fatigued by over exertion, the identical individuals ascended the sides of the same jars and phials with considerable difficulty, falling from them in numerous instances, and they were entirely incapacitated for adhering to them in an inverted position; yet when their physical energy was restored by repose, or an increase of temperature, they again repeated their most extraordinary feats with all their original promptness and dexterity.

Flies which are unable to maintain an inverted position on

highly polished bodies will frequently adhere firmly, with their backs downward, to glass rather defective in polish, or slightly soiled; indeed, I may remark generally, that the results of experiments, similar to those detailed above, will always be modified by the vigour of the insects and the state of the glass vessels with regard to cleanness and polish.

These facts plainly indicate that flies are not supported on the vertical sides of smooth bodies by the pressure of the atmosphere, nor by the aid of a glutinous secretion, but by means strictly mechanical, as Dr. Hooke has suggested: he erred, however, in supposing that the hairs on the underside of the tarsal membranes are pointed, and that there is a smoky substance on glass which they penetrate. One other link in the chain of evidence was wanting to place the matter beyond all dispute, and that, the kindness of Mr. W. Hadfield of Cornbrook has enabled me to supply. With his assistance, and the help of his air-pump, it was demonstrated to the entire satisfaction of several intelligent gentlemen present, that the House-fly, while it retains its vital powers unimpaired, can not only traverse the upright sides, but even the interior of the dome of an exhausted receiver; and that the cause of its relaxing its hold and ultimately falling from the station it occupies, is a diminution of muscular force attributable to impeded respiration.

Having thus established the mechanical theory of the movements of flies on polished perpendicular surfaces, I shall offer a few remarks on the apparatus by whose instrumentality they accomplish their purpose. In structure and function it bears the closest analogy to the pulvilli of insects, which, if named with reference to the most important office they perform, should be termed holders or supporters. It consists of expanded membranes, varying in size, figure, and number in different species, the edges of which are plain, not serrated, as Sir E. Home asserts,

asserts, though when placed in such a situation relative to the eye of the observer that the hairs connected with them are foreshortened, they certainly present an appearance which, on a superficial view, might lead to the latter conclusion. If the slender bristles on the inferior surface of the pulvilli of some of the larger *Coleoptera*, *Prionus cervicornis* for example, be very highly magnified, each, beside the numerous short hairs which project from its sides, will be found to have a small dense brush of exceedingly minute hairs at its extremity; and as the hairs on the pulvilli of flies, and many other insects belonging to various orders and genera, with which I have experimented, perform a function similar to that exercised by the bristles, and also exhibit a striking resemblance to them in external appearance, it is extremely probable that they are analogous in structure; though from the smallness of their dimensions, I have not yet been able to satisfy myself that this is the case by direct observation, notwithstanding I have employed the highest magnifying power at my command. The hold which insects are enabled to take of any roughness or irregularity of surface by means of the fine hairs composing the brushes must be very considerable; and whoever examines the most carefully polished glass in a favourable light with a powerful lens, will speedily be convinced that it is not free from flaws and imperfections.

That some species of spiders can support themselves against gravity on the sides of polished bodies by the assistance of a mechanical apparatus similar in principle to that employed by insects in like circumstances, I have announced in a communication recently made to the Linnean Society*; and the fact affords a strong collateral proof of the truth of my theory.

I am aware that the males of several aquatic beetles have the tarsi of the first and second pair of legs supplied on the under-

* See preceding paper, "On the Structure and Economy of Spiders."

side with numerous cup-shaped suckers of various sizes, which have their edges (the larger ones at least) beautifully fringed with delicate hairs. These suckers, which probably serve to facilitate the intercourse of the sexes, are remarkably conspicuous on the tarsi of the males of a very common species, *Dyticus marginalis*, and unquestionably give them a firm hold of smooth objects occurring in water, a liquid whose specific gravity rather exceeds their own; but that they are inadequate to the support of this insect, the average weight of which is about twenty-eight grains, on the vertical sides of dry, polished bodies, in so rare a medium as air, I have had frequent opportunities of remarking. My chief object in adverting to these singular organs on the present occasion, is to guard entomologists against the error of supposing that they correspond to the pulvilli of insects, which, as I have endeavoured to show, differ from them essentially both in structure and function.